

Low Power Performance of the LHP with Different Wick Materials

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Loop Heat Pipes (LHP) traditionally use sintered nickel primary wicks. Sintered nickel is currently the best wick material on the market. High capillary pressure and permeability make it almost irreplaceable for the high power large LHP, which are currently used widely for different space applications.

The LHP technology was never seriously considered for the very low power applications such as precision temperature control of payload components and instruments. The recent investigations and design attempts to create the miniature LHP with a few watt startup and operating power have indicated the nickel wick to be not very effective. The poor conductance and random difficulties to start up the LHP at very low powers on the order of 1-3 watt is forcing industry to develop a LHP design with improved performance. The JPL testing of the passive cooling system for the Mars Rover application developed in 1999 has indicated several areas for improvement: low conductance and some difficulties with a startup. The design used in this LHP relied on a nickel primary wick. However, the LHP performed without any serious problems at power levels above 20 watts.

The main reason, which affects conductance and startup parameters in the "classical" LHP is the heat leak to the compensation chamber from the evaporator. The traditional bayonet design of the evaporator creates the "liquid core" space inside the wick, which surrounds the bayonet liquid return line. This liquid core is a part of the compensation chamber, therefore any heat leak to this core will affect the thermal balance of the compensation chamber and cause degradation of conductance and startup parameters. The area of this liquid core is significant and the only part which separates compensation chamber and the wick OD is the relatively thin wall of the primary wick. The heat penetrated through the wall is in direct proportion with the conduction of the wall material - wick material. Nickel is rather high conductive material, therefore the heat leak through the wick into the compensation chamber plays a significant role in the overall thermal balance. This large heat leak causes difficulties in low power startup. The superheat of the evaporator temperature over the compensation chamber temperature, which is required to initiate the circulation in the LHP, can not be built at low powers. The heat leak into the compensation chamber from the evaporator will keep rising its temperature. Both of temperatures rise at the same rate, resulting in the required superheat being not developed and consequently the LHP not starting up.

A simple straight-forward solution for this problem is to change the wick material. At low powers there is no need for high capillary pressure supported by the wick; normal LHP uses just a fraction of a percent of the available capillary pressure. Therefore lowering the wick thermal conductivity will increase conductance and improve startup.

The Miniature LHP, which was initially tested with the nickel wick, was refurbished and a titanium wick was installed in the evaporator. The paper to be presented describes the aspects of the wick material performance which influences the LHP performance. The direct comparison of two evaporators with identical designs and different wick materials installed into the same LHP will also be presented. It is recommended, as a conclusion, that the titanium wick structures must be used in the low power applications that require good conductance, and whose startup requirements at low powers are exceed the capabilities of the nickel wicks.